

BOOK REVIEWS

Life, Temperature, and the Earth: The Self-Organizing Biosphere. David Schwartzman. 1999. Columbia University Press, New York, NY. 241 p. \$54.50, hardcover.

This book discusses, in very interesting fashion, the Gaia concept. That is, the concept that the atmosphere, the soil, and the oceans interact with living things to yield an interactive, self-regulating system. This is not a new concept. It has been around for at least 30 years.

Schwartzman's contribution is to bring not only his 15 years of research background in the area, but also to update and summarize new information in this relatively brief but readable book.

In Chapter 1, the author describes his theory of how our biosphere evolved through some 4 billion years. The impact of temperature fluctuation and the resultant diversity of habitats for life are briefly described. Schwartzman presents data describing how temperature was and is a critical constraint in biotic evolution. The author then makes a case for biotic evolution on Earth-like planets elsewhere.

Although temperature is an important consideration, the evolution from a reducing to an oxidative environment is not underemphasized by the author in Chapter 1. Prior to about 2 billion years ago, the atmospheric pO_2 levels were very low to almost non-existent. Before about 2 billion years ago most oxygen was bound either in water or in rocks and other chemical structures. There are those however, that disagree with this timeline. The rest of Chapter 1 is a synopsis of the Gaia concept. Further chapters expand various areas of this concept.

The Gaia hypothesis is a rather radical conception of co-evolution of biology and geology. Previous hypotheses did not emphasize the interrelationship and the feedback mechanisms that appear in the Gaia concept. The history of the concept is described in the latter parts of Chapter 1. This is "must" reading for anyone interested in interactions of the biosphere and earth's geology. The extrapolation of the basic concepts of Gaia to other worlds is fascinating. While working at the Jet Propulsion Laboratory in the 1960s, James Lovelock looked at spacecraft data and concluded that the atmospheric and geologic information from Mars orbiters and landers should indicate the presence or absence of life. Habitability, on earth or elsewhere, is not just "dumb-luck" but a result of continuous biotic interaction with the other components of the biosphere.

In Chapter 2, Schwartzman looks at the carbon cycle in detail. Although little of this information is new, it is well summarized by the author. Chapter 3 discusses a theory that has been around for a long time, the "faint young sun paradox." Carl Sagan and others had suggested that the sun of 2 billion years ago was not as hot, or at least not as luminescent as today. Thus less heat was available to heat the atmosphere of earth, yet the presence of greenhouse gases in the earth's atmosphere would create a barrier to heat-loss. Still others of more recent vintage argue that the sun had a higher mass and greater luminosity at 2 billion years of age. Thus there

was no need for a greenhouse effect and that such gases were less necessary to the model. The chemical composition of the earth's crust, over time, also played a role in temperature stabilization. In this respect the discussion of the silicate-carbonate geochemical cycle is excellent. Although the author's discussion of the contribution of pCO_2 levels on the carbonate-silicate cycle is good, it could possibly be expanded.

Chapter 4 is one of the best summaries I have read on weathering and its impact on the biota. The author's discussion of microenvironments and their impact on microorganisms is well done. The conclusion that organic acids, from microbial metabolism, have a great impact on minerals such as basalt and thus contribute to the silicate-carbonate microenvironment, is interesting. Further, a discussion of the production of microbial "crusts" and stabilized soil by algae and lichens and the inherent ability of such soil to resist erosion has far-reaching implications.

Chapter 5 expands upon the idea of the biotic enhancement of weathering especially related to the present time. Although the photography used in the book is black and white, there are some excellent photomicrographs in Chapter 5.

In Chapter 6, the author presents various quantification models for the biotic enhancement of weathering. Chapters 7 and 8 look at the earth surface temperature in more detail. Chapter 7 details the geothermal history of earth; while Chapter 8 looks at the question of temperature and oxygen constraints on microbial evolution.

Chapters 9 and 10 describe the basic concepts and make a case that the earth's biosphere with the geochemical parameters present at the onset 4 billion years ago, was destined to occur. Chance had little to do with the outcome. Chemical equilibrium must be maintained; homeostasis must be maintained; and thus the Gaia hypothesis is supported.

In Chapter 10, the criteria presented in Chapter 9 are applied to alien biospheres. Although I found little new in this chapter regarding habitable planets and the potential habitable zones about sun-like stars, the imposition of the Gaia hypothesis in the currently accepted data is interesting and helpful to our understanding of potential extraterrestrial life. Chapter 11 is a conclusion and summary chapter.

Overall, the book was well written, useful, and is packed with information. The idea that temperature and pO_2/pCO_2 evolved to give rise to an active bio-geosphere is not new.

Although I did not find all that much startling in the book, I found it contained a wealth of information that would ordinarily require a great deal of effort to put together from diverse sources. There are suggested readings throughout the book and an in-depth bibliography. The photos and photomicrographs are well done and contribute to the overall discussion, as do the tables and figures.

I recommend the book to anyone interested in bio-evolution bio-geology and almost any area of general biology. It is a concise, well written but easy to read effort. The author's style is conducive to most audiences.

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